

## Physical Science.

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The following communication was received too late to be inserted in its proper place, but as the writer was desirous to have it published in the same volume with the article to which it is a reply, the Committee have judged it better to place it thus out of order, than to postpone it to the next volume.

COM. PUB.

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

*Remarks on Mr. Espy's Theory of Centripetal Storms, including a Refutation of his Positions relative to the Storm of September 3rd, 1821: with some Notice of the Fallacies which appear in his Examinations of other Storms.*  
By W. C. REDFIELD.

The practical importance of the investigations which relate to the character and courses of our great storms, will be deemed sufficient apology for this communication.

Early in the year 1831, an article on storms appeared in the *American Journal of Science*,\* the main objects of which were, to point out the relative or whirling character of the great storms which visit the Atlantic coast, their origin in the intertropical latitudes; the circuitous or semi-elliptical character of their several paths or orbits; the general uniformity of their courses through the tropical and temperate latitudes; and the obvious cause for the continued depression of the barometer which is found in the centrifugal influence of their rotary action.

In drawing up this paper, I deemed it not inappropriate to exhibit the origin of the views or conclusions therein maintained; they having been first suggested by extensive personal observations of the phenomena of the storm of September 3d, 1821, in the states of Connecticut and Massachusetts, and confirmed by numerous personal inquiries, made at that period, of ship masters and other intelligent persons who had observed its action. I also added, in a very condensed form, such marine reports relating to this storm as appeared to afford further information. My statements, as then published, were copied extensively into the newspapers of the day, and had a wide circulation among the intelligent inhabitants of New England, who had witnessed the effects of this storm; and, so far as I know, their general accuracy has never been called in question.

Having shown the origin of my investigations, I proceeded to a more particular statement of the phenomena which were exhibited at various localities by the north-east storm which visited New York on the 17th of August, 1830; showing from an extensive collation of facts, its whirlwind character; its identity with the hurricane which visited certain islands in the West Indies five days before; its course, daily progress, and uniform character during this period; its further progress to the Banks of Newfoundland; and also its absolute identity with the E.N.E. S.E., S., S.W., and north-westerly gale which prevailed off this coast on the 17th, at or near the time when the gale was blowing at N.E. at New York and its vicinity. These results, which, for the most part, appear not to have been previously sus-

\* *Silliman's Journal* for April, 1831, vol. xx., p. 17—51.

pected, have been more fully generalized and illustrated in subsequent papers: and are also exhibited, in a most convincing manner, in the highly valuable work of Col. Reid on the Law of Storms, which has lately been published at London.

It appears, that since the results of the above inquiries have been brought before the public, Mr. Espy, of Philadelphia, in considering the laws of aqueous condensation, has been induced to believe that he has discovered the true cause of winds and all the various phenomena of storms which occur in our atmosphere.\* This theory, which he has set forth in a series of essays in this journal, appears to have formed the basis of his reports as chairman of a joint meteorological committee of the American Philosophical Society and the Franklin Institute.

The type of this new theory, or of the manner in which it is supposed to be exemplified, it is believed may be found in the movements of the air in a common chimney, or bonfire: but it appears to find little or no support in the facts which have been brought to notice during my inquiries into the phenomena of the Atlantic storms. Encouraged, however, by plausible, but erroneous inductions, made from the phenomena of the New Brunswick tornado in June 1835,† and by friendly, though perhaps injudicious support and announcements from highly respectable sources; and aided also (with few exceptions) by the favour and guardianship of the Philadelphia press, Mr. Espy has continued to labour with assiduity for the establishment of his theory.

In a brief introduction to his essays in April, 1836, Mr. Espy announced that "he had collected such a mass of facts as would place his newly discovered theory on an immovable foundation;" and that his readers would find developed in his essays "a law" which explains at once "all the seven phenomena of rain, hail, and snow, water-spouts, land-spouts, winds, and barometric fluctuations.‡"

Of the manner in which this modest announcement has been sustained, and of the apparent errors or misapprehensions of facts and of the principles of science, which abound in these essays and subsequent papers, I forbear at this time to make inquiry. But in one of these essays, (August, 1836, p. 105—108,) he gives a constructive abstract of my account of the storm of 1821, which abstract is then claimed to be inconsistent with a horizontal whirlwind, and he adduces these constructive phenomena, as "proving with irresistible evidence the existence of an upward vortex in this storm;" meaning here, by a vortex, not a gyrative movement, but a chimney-like motion.§ He also treats as an unwarranted conclusion, the observed fact, that "*along the central portion of the track, the storm was violent from the south-eastern quarter, changing suddenly to an opposite direction.* Disregarding, also, an important portion of the evidence, he then proceeds to assert, without, however, offering any proof, "that it was on the S.E. side of the storm at which the wind set in S. of E.," and further, that he could not find that the wind had changed from the S.E. to the N.W. quarter, as I had represented.

To this effort to set aside the results of my observations and inquiries, I

\* Jour. Frank. Inst. vol. xvii., p. 240 vol. xxiii., p. 153, &c.

† Some incidental remarks on this tornado will be published in the June number of this Journal.

‡ Journal Frank. Inst., April, 1836, vol. xvii., p. 240.

§ Ibid, August, 1836, vol. xviii., p. 105.

replied in a communication which appeared in this Journal for February, 1837; (vol. xix., p. 112—127,) to which the reader is now referred.

It must appear obvious, however, to Mr. Espy, that the action of the Atlantic storms, as developed by my own inquiries and those of Col. Reid, cannot be reconciled with his supposed centripetal movement of the winds, *even for hundreds of miles*, in nearly right lines from all sides towards the centre of the storm;\* and hence the renewed attempt which we now find in the March number of this Journal, to invalidate the facts which I had adduced, and to obscure or pervert their plain and obvious bearing.

In the freedom and candour of these prefatory remarks, it is by no means intended to impeach the sincerity or integrity of Mr. Espy, in any of his strictures or positions: but the strong bias which has apparently resulted from having preoccupied his mind with the speculations which he connects with his favourite theory, causes him to "suspect" every fact or conclusion which militates with his cherished conceptions, and to press into his service nearly all the heterogeneous phenomena in nature. This seems to disqualify him, at least in a measure, for instituting a rigid and impartial system of inquiry, suited to the present state of knowledge, and to the obvious demands of his assumed position, as a reformer in meteorological science. It appears to have been the misfortune of Mr. E. to have commenced his labours at the very point where, if successful, they should have terminated; viz. in establishing a general theory of atmospheric physics, resting on the basis of observation and strict induction in every class of natural phenomena which are sought to be comprised in his system. The attempt to explain nearly all the physical phenomena of the atmosphere by the theory of aqueous condensation, is not unlike that of him, who, in essaying to climb, should commence at the last and highest step in the ladder. In so diffuse and complex a science as meteorology, it is not by this inverted Baconian process that we can expect to "ascend from effects to their causes."

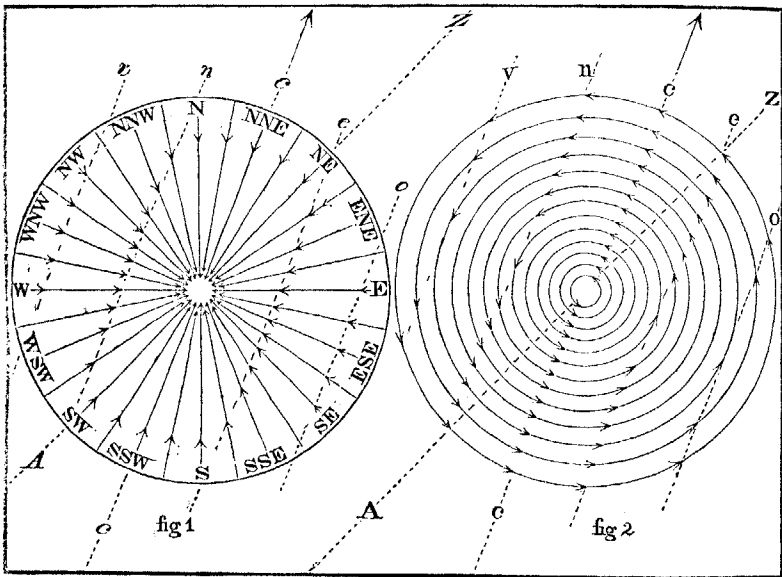
I have already glanced at the physical impracticability of a centripetal movement in the atmosphere, over a surface of several hundred miles in diameter, towards the centre of a storm; where, instead of the accumulation which must inevitably result from this movement in the air, its state of diffusion is known, by the indications of the barometer, to be unusually increased. But, for the purpose of examination, we may assume the theory; and we may then expect that when a storm moves along the coast of the United States, from the tropical latitudes, the wind, *on the centre of its path*, will set in from N.E., and so continue till the centre of the storm itself shall arrive, when, after a short lull, or a very rapid change, it must change to S.W., and blow in this last direction to the end of the storm; while, on the N.W. border of the centripetal storm, it should *commence from nearly N.W.*, and be of comparatively short duration, and showing little change in its direction.

But, on the contrary, if the storm be of a whirlwind character, and revolving to the left around its own central lull, or axis, then, if regularly exhibited, the N.E. wind at its commencement must pertain to the left hand

\* It should here be kept in mind, that half of the entire atmosphere lies below the height of three and a half miles. I have also good reasons for believing that the entire masses of our storms lie beneath this comparatively small elevation. What space for the exhibition of a vast centripetal column, whose semi-diameter is even imagined to have extended, in one case, from Iceland to Italy! See Journ. Frank. Inst. Oct. 1836, vol. xviii., p. 241, 242.

portion of the storm, (N. W. of its centre) and, as the storm advances, will change by the N. to the N. W. quarter. While on the centre of its path, the wind must set in from near to S. E., blowing across the track of the storm, and when the axis, or lull, has passed, the wind will be found in the N. W. quarter, blowing across the track of the storm, in the direction opposite from the commencement: and in places near to which the lull of the storm may pass, the wind will veer round, more or less suddenly, in proportion to the distance, towards the direction which is opposite from its commencement.

For the illustration of these positions, I refer to the annexed figures, the first of which illustrates Mr. Espy's centripetal theory, as applied to the storm of 1821; which, in the latitude of Philadelphia, was moving nearly N. N. E., as indicated by the line and arrow head *c, c*. Fig. 2 illustrates the rotary or whirlwind theory as applied to the same storm; which, in its advance, would be intersected by the several geographical stations, *v, n, c, e, o*, on the several lines of arrow heads which are found in line with these stations on both figures. The direction of the several arrow heads represents the direction, as well as the order of changes, which the wind would present to an observer, at each of these stations, according to the two theories.



A supposed variation of the course of the storm, and of the lines of intersection on the two figures, to N. E., parallel with the lines *A, Z*, may serve to illustrate the application of the two theories to storms that move in a N. E. direction, which is their more general course in these latitudes.

The foregoing remarks and illustrations are deemed necessary for a right understanding of the subject before us.

The positions of Mr. Espy which I propose at this time to refute, are found in his Examination of Col. Reid's Law of Storms; in a portion thereof

which he states to have been written in his official capacity as meteorologist of the joint committee at Philadelphia, but not accepted by the committee. He here proposes to "demonstrate" that the storm of Sept. 3d, 1821,\* was not "exhibited in the form of a whirlwind, but was like the twelve storms which have been investigated [?] by the joint committee of the American Philosophical Society and the Franklin Institute, that is, that the wind blew inwards at its borders." He says, "this conclusion is rendered certain by the following facts, [allegations?] which are deductions from the particulars given below."—We shall see.

*First position.* "The storm set in every where on the extreme S.E. border from the S.E., and not from the S.W., and changed round to the S.S.W. or S. And on the extreme N.W. border it set in from N.N.E., and blew hardest from the N. and N.W. Now, on the extreme S.E. border, it could not blow from the S.E. at all, on the supposition it was a whirlwind; nor, on the N.W. side, could it blow at all from the N.W. Both facts, however, are not only consistent with a centripetal motion of the air, but absolutely prove it." p. 149, March number of this Journal.

That by the "extreme S.E. border," is here meant the extreme outward limit of the storm in that direction, is evident; for, assuming, as he appears to do, that the course of the storm was N.E., it is only upon "the extreme border," according to his own theory, that the storm could set in at S.E.; and because the position would otherwise be destitute of any discriminating value.

We begin with the two positive allegations: 1st, "The storm set in every where on the extreme S.E. border from the S.E.;" and 2d, "On the extreme N.W. border it set in from N.N.E.;" From the evidence recited as supporting the alleged facts, we find a wide portion of the central track of the storm on which it is reported as beginning at S.E., viz: from the coast of Maryland, and New Jersey, and thence on a line through Bridgeport and Middletown, Conn., on one side, to an unknown point off Cape Hatteras, and a line drawn from thence, at a distance from the coast not well ascertained, but passing perhaps through the towns of Providence and Boston on the other.† Now, what evidence has Mr. Espy adduced, that the easternmost general limit here alluded to, was "the extreme S.E. border of the storm?" On this supposed limit, we find the storm raging with violence, and this wind could not here have sprung instantaneously into action, but must have swept from a greater distance, though doubtless with a diminishing force and modified direction, as it became more remote from the axis of the storm.

But we are not left to this obvious conclusion: for we find in the evidence adduced, that "a vessel from Bermuda experienced the gale from the westward on the inner edge of the Gulf Stream." Probably from the S.W. quarter, i. e. *westward of the meridian*, a colloquialism common with nautical men; and on any construction, this statement alone refutes the position.

We find, 2d, "in lat. 38° 30', on the inner edge of the Gulf Stream, *gale from the westward.*" This also agrees with the foregoing, and disproves the position.

\* Journ. Frank. Inst., March, 1839, vol. xxiii., p. 149—158.

† It is my own opinion, that the S.E. wind was not found eastward of a line passing through New London and Worcester, but newspaper reports have given the direction at S.E. in general terms, to the extent here mentioned, where I suppose the storm was S.S.E. nearly, or at best S.E. by S., in the early part of the gale.

3. We have also reported in lat.  $38^{\circ} 30'$ , lon.  $74^{\circ} 30'$ , gale S. by E. Whether this longitude be printed correctly or otherwise, this report contradicts the position. It is true also that we find "a ship from Boston to Norfolk [Bristol Trader, three days out,] in lat.  $40^{\circ} 19'$ ; weather foggy, and light winds from S.E.;" but she had met with head winds, and judging from the position of Nantucket shoals, it appears not probable that she was westward of their meridian, and she may have been much further to the eastward;\* and to assume a direct connexion and identity of these exterior "light winds from S.E.," with the S.E. gale in Connecticut, is assuming the very point which is necessary to be proved; and such a conclusion, it will be seen, is contravened by other facts.

I now submit further evidence, to show that the border here claimed was not the extreme border, and also, that as we proceed from the centre of the path of the gale towards its eastern border, it was found to commence from a point southward of S.E., which could not happen according to Mr. Espy's theory, as may be seen by referring to fig. 1.

4. We have accounts of the gale eastward of the Bay of Rhode Island, and in Bristol harbour a vessel was driven on shore: probably not by a S. E. wind.

5. The ship *Camillus*, Peck, from Greenock, which arrived at New York on the 7th September, experienced the first part of the gale from S.S.E.

6. Schooner *Juno*, Low, from Aux Cayes, reported at Salem, September 5. On Monday morning, Sept. 3d, saw a dismasted vessel, eight leagues E. of Cape Cod. Had a heavy blow on Monday night, at S.S.E., and a very high sea running.

We thus see, in part from Mr. Espy's own evidence, that his "extreme S.E. border" of the storm is a mistaken assumption, and that his extreme S. E. wind (which, upon his theory, should have been E. S.E., as the course of the storm in this latitude was nearly N.N.E.) has been already traced round to S.S.E., and, could the inquiry be carried out, I have no doubt we might follow it round to the westward of the meridian, as experienced by the vessel from Bermuda.

We proceed now to the supposed "extreme N.W. border," where it is alleged that the storm "set in from N.N.E." I might, however, rest contented with this allegation; for the admission that the storm here set in from N.N.E., i. e. in the direction which is contrary to the progress of the storm, is in strict accordance with the whirlwind theory, and fatal to his own, which would here require the wind at W.N.W., or nearly; while his N.N.E. wind should be confined to the centre of the track, and yet Mr. Espy here makes the unfortunate assertion, that such facts as these are not only consistent with a centripetal motion of the air, but absolutely prove it!

The only places I find mentioned where the gale is said to have set in at N.N.E., is in one of the reports from Norfolk, and another from Bombay Hook, near the head of Delaware Bay, from both which places the other accounts say N.E.; but in one of these points of direction, (N.E.) Mr. E. has fixed the centre of the storm, and the gale was heavy on this line of track: how, then, does he find here "the extreme N.W. border?" But more of this as we proceed.

\* This last supposition appears not only probable, but almost certain, from this fact, that the ship *Camillus*, from Greenock for New York, was up with Nantucket about three days before the gale, but was unable to get to the westward if not driven back; so that she took this gale at S.S.E., and did not then arrive till the 7th.

*Second position.* "Wherever the wind set in from the E., it always changed round by the S., which is consistent with the centripetal, and inconsistent with the centrifugal, theory." p. 149.

The entire want of arrangement in the facts collected by Mr. Espy, somewhat impedes the inquiry; but on examination, I find mention of only three places where the gale is said to have set in at E., viz. off Roanoke; in some of the accounts from New York; and in a letter from on board steamboat Connecticut, which went that day from New York to New Haven. Of these, the report from Roanoke represents the wind not as changing "round by the S." but first at E., and then S.W. At New York also, no mention is made of a change from the E. round by S. The "wherever" would appear, therefore, to be found only at, or near, New Haven. Here, it is true, the wind "changed round," not from E., but from S.E., "by the S.," as it *should do*, (except on the line of lull,) according to both theories, (see figures.) Intelligent friends, (one a ship master,) then on board the Connecticut, assured me that the gale here set in nearly from S.E., and hauled somewhat suddenly to the S. and S.W., (owing, as I suppose, to the near proximity of the lull at that time,) and by this change the Connecticut was driven from her anchors and cast on shore at Morris' Cove, East Haven. It was within my own observation, also, that trees prostrated by the first part of the gale in New Haven and its vicinity, pointed, not to the W., but N.W., or more northerly, showing a S.E. or S.S.E. wind, and numbers of these indubitable records remained in this position for years, some nearly to this day. The observations made at New Haven, for the Connecticut Academy of Arts and Sciences, (and furnished to Mr. Espy by Mr. Rich, now a member of Yale College,) also fix the wind at S.E. Nor does it appear, on any theory, how the wind could have been more eastward at New Haven, than at Bridgeport and Middletown, where the printed reports state it to have been S.E. The position, therefore, fails.

*Third position.* "There never was a lull mentioned, only where the wind set in from the N.E., which has the same bearing as before, for the centre of the storm only can have a lull." p. 149.

Let us try this allegation by the evidence then before Mr. Espy.

1st. In the marine reports, from localities where the gale set in from S.E. to E., we may rightly infer the presence of the lull from the phenomena which are expressly mentioned. As, off Roanoke, "a dreadful gale at E.,\* then S.W.," (p. 153) for we know that the gale seldom shifts to nearly the opposite quarter, without an intervening lull. Again, at sea, 40 miles N. of Cape Henry, severe gale from S.E., *changing to N.W.*" The last remark applies still more strongly to this report. To which I may add as positive evidence, (not, however, then before Mr. Espy) that a shipmaster, whose vessel was driven on shore to the southward of Cape Henlopen, with the wind "right on shore," also described to me the sudden lull, and the ensuing blast from W.N.W. Also, the schooner Mark Time, from Norfolk, (New York Gazette, September 7,) experienced the gale from S.E. off Chincoteague, Md., *was thrown upon her beam ends*, and remained an hour in that position, when *the shift of wind to the westward righted her*. This vessel would hardly have lived so long in this position, except she had fallen into

\* It should be noted, that an E. wind in this part of the track, where the course of the storm was nearly N., corresponds, in the character of its changes, to an E.S.E. wind in the latitude of Philadelphia, where the course of the storm, or the curve of its track had changed to nearly N.N.E.

the lull, and being righted by the sudden shifting of the wind, might fairly imply, that after the lull, it had suddenly come out from the opposite quarter.

2d. "At Cape Henlopen, Delaware, the hurricane commenced at half past 11 A. M., from E. S. E.; shifted in 20 minutes to E. N. E., and blew for nearly an hour. *A calm of half an hour succeeded*, and the wind then shifted to W. N. W., and blew, if possible, with still greater violence," p. 154. Here, certainly, is mention of a lull, and no mention of a N. E. wind.

3d. The National Gazette, adduced by Mr. Espy, states: "At Cape May, from 1 P. M. till half past four, the wind blew a violent hurricane from S. E.," p. 158; and my own reports (p. 154) state that the gale here "commenced at N. E. at 2 P. M., and veered to S. E., and blew with great violence,—*after abating 15 minutes*, it again blew with increased violence for two hours, and then abated." The direction of the wind, after the lull, is not stated, but being the close of the storm, it was doubtless from the westward, as at Cape Henlopen, which is distant but 13 miles, and nearly in the line of the storm. Here is the only pretence which I can find for connecting the lull with a N. E. wind, which the collation of accounts shows to be an error, or at best only an incipient wind at Cape May, and not the true easterly wind of the gale. But further:

4th. "This storm, as experienced in the central parts of Connecticut, commenced blowing violently from E. S. E. and S. E. about six o'clock in the evening of the 3d day of September, having been preceded by a fresh wind from the southern quarter, [from S. or S. S. E.,] and flying clouds. It continued blowing in heavy gusts with increasing fury, till about 10 o'clock, P. M., when the wind suddenly subsided. A calm, or *lull*, of perhaps fifteen minutes duration ensued, which was terminated by a violent gust from the N. W., which continued till about 11 P. M., and then [i. e. from that time,] gradually abated." (Silliman's Journal, April, 1831, vol. xx., p. 20.) This (which lay before Mr. Espy) was the testimony of an actual observer, who resided on the ground, was familiar with the points of the compass as connected with the winds, from his boyhood, and had the best possible reasons for knowing the direction and strength of this gale; who had then formed no theories on the subject; who for months, and even years, afterwards, had also before him nature's own records of the direction of the wind, as exhibited in the prostration of the orchards and forest trees; and who is perhaps the only person living who made extensive and careful observations and inquiries on these points at the period of the storm.

Of the surprising character of this allegation, "that there never was a lull mentioned, only where the wind set in from the N. E.," it does not become me to speak; but I infer that Mr. Espy has here drawn mainly upon the centripetal image existing in his own mind, rather than upon the recorded observations which lay before him.

Having thus shown the error of this statement, and that the lull was on or near the line of S. E. wind, and as Mr. Espy also here admits that the centre of the storm only can have a lull, it appears to follow that "this storm was exhibited in the form of a great whirlwind," as I had previously maintained; for the point here discussed, involves the main question between the two theories.

*Fourth position.* "Where the wind set in from the S. E., there is no lull mentioned previous to a change of wind, and in no instance could I find that it changed round to N. W. Two instances are given by Mr. Redfield, one at Bridgeport, Conn., which I find is incorrectly reported, [?] and instead



of changing round to N.W., it should read S.W.:—the other at sea, 40 miles N. of Cape Henry; this I could not find, and I suspect there is something wrong in it, for 40 miles N. of Cape Henry is not at sea, but in the eastern shore of Virginia. [1] At other places in a right line with this, it set in from the N.E., e. g. at Cape May and Norfolk." p. 149—150.

The first assertion here, that "where the wind set in from the S.E. there is no lull mentioned previous to a change of wind," is refuted by the facts just reviewed; this being a reiteration of the foregoing position in another form. But he here says: "*in no instance* could I find that it [the S.E. wind] changed round to N.W." The value of this extraordinary assertion has also been seen.

Unfortunately, it appears that two of my cases have been "*suspected*" by Mr. Espy as being contrary to his theory.\* We have before heard of his finding of the error at Bridgeport, where, by his showing, "the wind commenced blowing hard from S.E. about 6 P. M., and continued to increase in violence *till about 9 P. M.*, [the italics are mine] when the tempest raged with a degree of fury the most awful and destructive. The storm continued with unabated force until near 11 P. M., when the wind hauled round to S.W., and gradually abated."

I see nothing in this account to support Mr. Espy, except the obvious omission to state the direction of the wind from 9 to 11: for we know that the centre, or axis, of the storm, which, from the indications of the barometer, we find to have been opposite to New York at 7h. 30m. P. M.,† must have passed Bridgeport at, or soon after, 9, about the time which my information fixes the change at New Haven, and was at Middletown and Hartford about 10; and immediately after this crisis of the gale, the wind is known to have been blowing from the N.W. quarter on all this line. Neither have we any reason to doubt the account from which my own statement was taken. After 11, i. e. two hours *after* the passage of the centre of the storm, "the wind hauled round [from N.W.?] to S.W., and gradually subsided." My own knowledge, and inquiries made at the time, corroborate this view of the facts.‡

The observations made "at sea, 40 miles N. of Cape Henry," it appears are set aside, because that 40 miles *due* N. of that Cape is on land, "in the eastern shore of Virginia"! This is quite unworthy of Mr. Espy and of his cause; for who did not perceive, that by this phrase was meant, 40 miles from Cape Henry, on the usual route of vessels bound northward. On this subject I find the following:—

*Norfolk, Sept. 9th, 1821.* Arrived, sloop *Atalanta*, Philips, of Swansey, bound to Charleston. August 26, off Cape Hatteras, close in with the land, experienced a severe gale from S.E., which split her sails to ribbons, and made it necessary to put into the first port. On the 3d instant, about 40 miles N. of Cape Henry, experienced another severe gale from S.E., which hauled round soon after to N.W.; which made the A.'s situation so embarrassing, that it was with difficulty she could be got in.

\* Journ. Frank. Inst., August, 1836, p. 105. I quote the italics.

† In the *New York American*, Sept. 4, I find the following facts communicated relating to the state of the barometer in this storm; at 6 A. M. 30.13—2 P. M., 30.05—6 P. M., 29.62—7 30 P. M., 29.38—8 P. M., 29.53—9 P. M.; 29.64—10 P. M., 29.07—the last, evidently a typographical, or a clerical, error.

‡ From the best estimates which I have been able to make of the course of the lull or centre of this storm, it would appear to have crossed Stratford Point and Milford, on the N. shore of L. I. Sound, passing between Bridgeport and New Haven, and perhaps nearly touching one, or both, of these places.

The worthy captain of the *Atalanta*, and his marine reporter at Norfolk, will doubtless be surprised on finding that the reported position of this vessel was "not at sea, but in the eastern shore of Virginia." The reader, however, will here perceive at least one other instance in which the S.E. wind *did* "change round to N.W."

It is strange enough that the "right line" of N.E. wind should have been located through Cape May, where, according to Mr. Espy's own showing, from the National Gazette of September 7th. "from 1 P. M. till half past 4, the wind blew a violent hurricane from S.E." p. 158. Instead of this, we find this line to have been through Edenton, Norfolk, Chesapeake Bay, Bombay Hook, and New Castle, Philadelphia, Trenton, and New Brunswick; at all which places, instead of a lull and opposite gale, the storm veered to N.W. I see nothing left, therefore, of this position.

*Fifth position.* "Along the seaboard, where the wind had been S. and S. E. all day, at the approach of the storm, it backed round towards the E. and E.N.E.; and inland, where the wind had been N.W., it backed round towards the N. and N.E., on the approach of the storm." p. 150.

I cannot perceive any relation which the direction of the wind, *previous* to the arrival of the storm, can have upon the question at issue. Nor do I perceive that this vast generalization of the previous winds, westward of the main line of the storm, is supported by any evidence, except by the single statement of the direction of the wind at Annapolis, at 4 A. M.

*Sixth position.* "Wherever the wind set in from the N.E., it ought not to have changed at all, according to the centrifugal theory, whereas it did always change round by the N. to N.W. or W., or by the S. to S.W., as it should do by the centrifugal theory." p. 150.

One fact is truly stated in this position, viz. that this gale, wherever it "set in [or continued to blow] from the N.E.," "it did actually" "change round by the N. to N.W. or W." But the alternative fact is not found, of a change [veering] from N.E. "by the S. to S.W., as it should [not] do by the centripetal theory." For this theory (supposing the course of the storm to be N.E.) requires the wind to remain unchanged till the arrival of the central lull, after which the wind should come out, with even greater strength, from the opposite quarter; or, if the point of observation be just without the lull, the change should then be very rapid, as the lull passes, (see figures 1 and 2.) The averment, that "according to the centrifugal theory," meaning, as I suppose, the whirlwind theory, the N.E. wind "ought not to have changed at all," is not only unfounded, but appears as difficult to account for as any which is found in any of these positions; as will appear by the illustrations above referred to.

I object, however, to the term "centrifugal," as here used: for no one, I believe, except Mr. Espy, ever talks of the wind blowing *outwards* from the centre, towards the circumference of a storm. The idea of the wind's blowing directly inward, and thence upward, or downward, and thence outward in all directions, in violent storms, of either large or small extent, I consider as being fanciful, and wholly opposed to all correct observations, as well as to the laws of motion and equilibrium, which pertain to both the ocean and the atmosphere.

*Seventh position.* "According to the centrifugal [whirlwind] theory, the wind never could change round, on the extreme N.W. boundary, from N. N.E. to N.W., as it did, according to the centripetal theory." p. 150.

All the strength of this position lies in the assumption, here repeated, (see position first) that the points from which the gale was reported at N.

N.E., were "on the extreme N.W. boundary" of the storm, an assumption apparently as gratuitous and unfounded as could well be made. We have already noticed the general line on which the first violence of the gale was experienced from the N.E., and I can find its direction, at this period, mentioned as N.N.E. only as follows, viz. in one of the accounts from Norfolk, (p. 154) one from Bombay Hook, (ibid.) and possibly by constructive inference, at Point Lookout, at the entrance of the Potomac, (p. 156) and one also at Philadelphia, (p. 157.) But at all these places, we find that the same accounts, or others, state the gale to have been N.E., on which line of wind Mr. Espy locates the centre of the storm. The reader will therefore be surprised to find this line, where the wind veered to N., N.N.E., and N.N.W., assumed also as "the extreme N.W. boundary" of the storm, where "the wind never could change round from the N.N.E. to the N.W., as it did," according to *either* theory.

The mere absence of reports from more western localities, would afford no good ground for this position; for the gale raged with destructive fury on the line here mentioned, which could not therefore have been its extreme border. It is true, that we have found it stated in my reports, that there was no *hurricane* felt at Baltimore; but the direction of the wind having been from off the land at that place, as well as less violent, there was no injury received, nor any cause for reporting a remarkable storm. That the storm, however, was experienced at Baltimore, I have never doubted, for the contrary supposition would be of the most incredible kind. Besides, Baltimore is but little out from the line of New Castle, &c. through Chesapeake Bay to Point Lookout; and I find, also, the following accounts which have not improbably met the eye of Mr. Espy, as part of the first is comprised in his details of evidence at page 156.

*Baltimore Sept. 6.* "The steamboat Norfolk left here on Monday morning, at 9 o'clock, and when she opened the bay, [only twelve miles from Baltimore, and early in the day,] felt the gale severely; but being before [it] proceeded without fear. Off Point Lookout, [N. point of the entrance of the Potomac] fell in with ship Repeater, Maxwell, who had anchored before the gale. During the gale, parted her small anchor, and capsized, and was fast driving on shore, when it was thought advisable to cut away her masts. The Norfolk fell in with her, and towed her to Norfolk."

Another account says, the schooner Alert, Beers, rode out the gale under St. Mary's, Md., i. e. in the Potomac.

I may add also, that Mr. Espy, in admitting that on the extreme N.W. boundary the wind did change from N.N.E. to N.W., has effectually refuted his own theory, as applied to this storm. See figure 1.

*Eighth position.* "On the extreme S.E. boundary, it could not blow at all from S.E. according to the centrifugal [whirlwind] theory: but it did, according to the centripetal theory, blow in that direction in many places on that border." p. 150.

It is here correctly stated that this storm (if blowing in the form of a regular whirlwind at its extremities) "could not blow at all from S.E. on the extreme S.E. boundary of its path;" for a like reason, that according to Mr. E.'s hypothesis, it could not blow from N.N.E. "on its extreme N.W. boundary;" but in here reiterating the assertion, (see first position) that "*it did*," according to the centripetal theory, blow in that direction in many places on that border, for six or eight hours during the whole strength of the gale," he appears to confute himself; for, 1st. The gale could not have exhibited this duration and "whole strength" upon its extreme border; for this would

be contrary to all our knowledge of this and other great storms; and 2d, we have already seen, that it was in places nearer to the centre of the storm where the gale set in at S.E., and where its duration was not only six or eight hours, but, with vessels drifting before the gale, was eight and ten hours; *the duration of the gale being found greater on the line where it set in from nearly S.E. than on any other portion of its track;* as it should be, according to the whirlwind theory. On no hypothesis, therefore, could these places where the storm set in from S.E. and exhibited such strength and duration, have been at its "extreme S.E. boundary." Other evidence deciding this point has already been considered: (see under first position.)

*Ninth position.* "On the extreme N.W. border, according to the centrifugal [whirlwind] theory, it could not blow the hardest from the N.W., nor on the extreme S.E. border could it blow the hardest from the S.E., as it did in exact conformity with the centripetal theory." p. 150.

We have been showing that on the "extreme borders" here mentioned, "it could not blow the hardest," on any theory. The error or fallacy of the position, lies in again assuming for the "extreme border," the interior of the storm's path. But, by what process, or evidence, Mr. E. discovers that on these extreme borders, "it did blow the hardest" from S.E. and N.W., and "in conformity with the centripetal theory," I am at a loss to discover. The evidence of the manner in which the gale *did* blow, as we have seen, affords no support to this conclusion. This new fact, that the wind blew "the hardest" at the very point from which it first commences to blow, appears to be a more extraordinary discovery than any yet made.

*Tenth position.* "At Cape May it changed round from N.E. by E., and at Cape Henlopen it changed round from N.E. by N., in conformity with the centripetal, and entirely contradictory to the centrifugal, [whirlwind] theory." p. 150.

There is much error in this. 1st, A change of wind "round from N.E. by N.," pronounced to be entirely contrary to the centrifugal [whirlwind] theory"! I forbear to comment on such a statement. But, 2d, can Mr. Espy inform us how this change from N.E. *both ways*, at or nearly on the same point or line of advance, can be in conformity with his centripetal theory? especially when we find from the reports that the central lull visited both places. We have seen, that on his hypothesis, the N.E. wind on the central line, supposing the storm moving N.E., should not veer at all, but, at the expiration of the central lull, should come out at S.W. nearly, and this last wind having all the progressive force and velocity of the storm to aid it, should here blow with far greater fury than the previous N.E. wind. We are told, elsewhere, however, that the centre of the gale passed between these two points. But the diameter of the lull was such as to give a duration of half an hour at one place, and fifteen minutes at the other, moving with the velocity of 30 miles an hour. The fact alleged, therefore, cannot be known, and is also improbable; for according to the charts and Coast Pilot, Cape May bears from Cape Henlopen N.E. by N., distant but  $12\frac{3}{4}$  miles, and the course of the gale being here N.N.E. nearly, would give a distance, *in the line of advance* between the two places, of less than three miles, while the diameter of the lull would appear, by these accounts, to have been at least fifteen miles.

At Cape Henlopen, "the gale commenced at half past 11 A. M. from E. S.E., and shifted in 20 minutes to E.N.E., blew very hard for nearly an hour, [evidently much longer,] a calm of half an hour then succeeded, and

the wind then shifted to the W.N.W., and blew, if possible, with still greater violence." Now, where do we find the wind, which, it is alleged, "at Cape Henlopen," changed round from N.E. by N., in conformity [?] with the centripetal theory." To show the error of this, I also add the following fact in relation to the direction of the wind at this place, viz. the pilot boat Oscar, Davis, of Wilmington, was driven ashore during the gale, about one mile S. of Cape Henlopen lighthouse, and the crew lost.\* How could a *pilot boat* be thus driven on shore by a "N.E. wind changing round by N.?"—or even by an E.N.E. wind. Can Mr. Espy inform us?

The mean of the accounts from these two capes, as before suggested, is probably an approximation to the true state of facts; and that the gale was not N.E. at these places, seems also apparent from the report from Morris River in the lower part of Delaware Bay, (N. J., and not Del., as previously given,) which states the gale there was "from E.S.E." And at Dennis' Creek, in the same vicinity, according to the reports collected by Mr. E., "the wind came on to blow about 2h. from the *eastward*, and continued to increase till about 5 P. M., when the wind *changed to the westward*, still blowing very heavy," (p. 157.) I also find reported from Mount Holly, in the interior of New Jersey, between the Delaware and the sea coast, a "heavy rain, with violent *east wind*." (N. Y. Gaz., Sept. 8.) These facts serve to show, most conclusively, that the line of N.E. wind was not over the Capes of Delaware, as claimed by Mr. Espy.

The errors here involved have also been shown in the refutations of the third, fourth, and seventh positions.

*Eleventh position.* "Both in Norfolk and New York, the wind set in from near the N.E., and at the termination blew from S.W., which is the *experimentum crucis* in favour of the centripetal theory, and utterly inconsistent with the other. [?] In like manner at Ocracoke, it set in at E.S.E., and terminated at S.S.W.; and out at sea, on the extreme eastern borders of the storm, the wind blew for eight or ten hours from S.E. and S. by E., with but little change, as it ought to do, if the wind does actually blow towards the centre of the storm." p. 150.

We shall find, that the setting in of the wind "from near N.E." at New York, does not very clearly appear; and it would seem to have been *after* the termination of the gale at the above places that the wind blew from the S.W. The important fact, that at these places the gale veered by the N., and blew its greatest strength before passing the N.W. point, is kept out of view, and appears fatal to the centripetal theory and its "*experimentum crucis*." The wind reported at Ocracoke "from E.S.E. hauling round to S.S.W.," accords with the regular whirlwind action of the storm, provided its centre passed inside of that anchorage, as it probably did, and from thence to sea across Currituck Sound, the line of progress here being N. or westward of that point; although it does not appear whether the phrase *hauling round* is used in its proper sense, or to express a more abrupt and general change of direction. We again find here, also, the singular assumption which has already been disposed of, and which, as now presented, amounts to this; that an undefined point of observation, which would appear to have been moving to the northward and westward before the gale and the Gulf Stream, so as to carry the gale for eight or ten hours with but little change, was actually "*in the extreme eastern border of the storm!*" Infer-

\* N. Y. Gazette, Sept. 8.

ences drawn from such positions as these, would seem to require no further refutation.

*Twelfth position.* "At the time the wind changed round to S.S.W. at Ocracoke, it was blowing at Norfolk a violent gale N.E., nearly towards Ocracoke. Now, as these places are 130 miles apart, and nearly on opposite sides of the storm at that moment, it is utterly impossible, according to the whirlwind theory, that the wind at Ocracoke should be blowing towards Norfolk, and, at the same time, the wind at Norfolk be blowing towards Ocracoke. And this fact is entirely consistent with the centripetal theory."

We have here, if I mistake not, a further specimen of the manner of confounding, or passing over, the essential distinctions of time, place, and direction, for which Mr. Espy's meteorological papers are so remarkable. The evidence laid before us is this: "At Ocracoke, at daylight, wind E.S.E., blowing a gale; *after* hauling round to S.S.W., ceased between 10 and 11 A. M. both at Ocracoke and Portsmouth." At Norfolk, after 10 A. M., the wind *commenced* blowing a gale from N.E.; from 11½ to 12½, it threatened a general demolition; about 12, the wind shifted to N.W., [one other account mentions the wind as changing from N.N.E. to N.N.W.,] and *continued* its fury half an hour longer; and at 4 o'clock, *the storm was over*, and the wind changed to S.W." The italics here are mine.

Now, 1st, as to time: The storm, it appears, ceased at Ocracoke between 10 and 11, and of course it blew from S.S.W. *before* this period, if at all; while at Norfolk the gale *commenced* blowing at N.E. *after* 10 o'clock. So much for the winds of this hurricane blowing at these two places "at the same time." 2, As to place and direction: a N.E. wind moving in a direct course from Norfolk for the distance of 130 miles, as protracted on Blunt's Chart, *would reach a point 120 miles W.N.W. from Ocracoke bar or inlet*; and this is called "blowing at Norfolk nearly towards Ocracoke"! We thus see, that the assumptions which are here made, fail altogether; but it will also be perceived, that there was sufficient time and space for the wind of the N.E. storm at Norfolk to turn towards the left, around the rapidly advancing axis of the whirlwind storm, without sweeping so far south as Ocracoke.

(TO BE CONTINUED.)

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**Progress of Practical and Theoretical Mechanics and Chemistry.**

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ARTICLES FROM THE FRENCH JOURNALS. TRANSLATED FOR THE JOURNAL OF THE FRANKLIN INSTITUTE, BY J. GRISCOM.

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*Salts Arising from Organic Bodies.* By M. V. REGNAULT.

In an elaborate memoir entitled "New Researches on the Composition of Organic Alkalies," it is stated by the author, in his conclusion, that "the preceding analyses show very clearly that all salts formed from organic bases with oxacids, include one atom of water necessary to their composition, and of which they cannot be deprived without undergoing decomposition. These bases, therefore, present a complete analogy with ammonia in its mode of action with acids. They combine directly with the hydracids without decomposition, forming hydrochlorates, and not chlorides, like

## Physical Science.

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

*Remarks on Mr. Espy's Theory of Centripetal Storms, including a Refutation of his Positions relative to the Storm of September 3rd, 1821: with some Notice of the Fallacies which appear in his Examinations of other Storms.*  
By W. C. REDFIELD.

(Concluded from p. 336.)

Having now done with Mr. Espy's array of numerical positions, we are next told that "the wind also changed round at Norfolk S.W. some time before it set in at New York. Also, two ships at sea, opposite the Jersey coast, had the wind blowing a gale from E.S.E. to S.S.E. At the same time, the wind was violent at Philadelphia and Reedy Island, [head of Delaware Bay] from N.N.E. to N.W. Now these places were nearly in opposite sides of the storm; the wind was therefore centripetal, as it blew from each towards the other." p. 150.

This is another example of the confusion of data above mentioned. The "same time" meaning only those long continued and undistinguishable portions of time, in which two ships "had the wind blowing a gale from E.S.E. to S.S.E., and at Philadelphia and Reedy Island, the whole time in which the gale was blowing and veering "from N.N.E. to N.W."! But if "these places were in nearly opposite sides of the storm," and "it blew from each towards the other," then we may suppose it to have blown from New York to Philadelphia, thence to Reedy Island, from this to the ships off the Jersey coast, and from the ships towards New York; while the natural current of S.W. wind at Norfolk was following after the storm. I might make a further analysis of this passage, but think it unnecessary.

The setting in of the N.E. wind at New York, requires, however, a distinct consideration. I had comprised the various reports from this city in my general statement, "from N.E. to E." One or two accounts say N.E., as does the report from Jersey City; while at the Quarantine at Staten Island, five miles below, where the direction would be most likely to be known, it is stated at E.S.E. or E. A majority of the city accounts which I have seen, also fix the onset of the gale from E. or E.N.E. It is only by a comparison of such reports that we can arrive at a reasonable conclusion, and the mean of all the accounts published at that day would be E. by N., probably near the truth. Mr. E. himself gives an account stating it at "E. S.E., veering to E. and E.N.E.," and another which fixes it at E. (p. 157;) and he can hardly be justified, therefore, in assuming it at N.E. But we have other facts which remove all doubt on this point. Of the ships at or near the quarantine, one\* or more was driven up the kilns, between Staten Island and Bergen Point. Also, the Hoboken ferry boat, which, after repeated trials, nearly reached the city, was blown off and reached the shore near Col. Stevens' (Hoboken.) (N. Y. Gaz. Sept. 7.) These facts cannot be reconciled with a N.E. wind. I may add here, that it is not uncommon to find errors of this kind made at New York; occasioned, perhaps, by re-

\* Ship Chase.

ferring the N. point to the course of the North River, or to Broadway, which are about N.N.E. and N.E. by N., respectively.

We are next told, that "while the storm was passing over Connecticut, the wind blew *constantly* in the S.E. corner from the S.E., while *at the same time*, in the N.W. corner of the state, the wind was blowing a furious gale from the N.W., and Mr. Redfield himself testifies, that the 'trees and corn in this corner of the state were uniformly prostrated towards the S.E., while even as far inland as Middletown, they were uniformly prostrated towards the N.W.'" p. 150, 151. The italics are mine:

We have here a further combination of errors, of a like character with the preceding. 1. In assuming that the wind blew "constantly" from the S.E. in the S.E. corner of Connecticut; for the gale here set in at S.E. or S.S.E., and veered round by S. as it passed over; a fact well known to me from the beginning, but not noticed in the newspaper accounts of the storm. 2. The "furious gale from the N.W." "in the N.W. corner of the state," was not as strong as the earlier S.E. gale in the central part of the state, and did not blow "at the same time" that the gale was south-easterly about New London; but at a later period, when the central portion of the storm had advanced into Massachusetts, and the gale had ended on the southern shores of Connecticut. 3. It was a north-easterly wind which prevailed in the N.W. corner of this state, "at the same time" with the south-easterly wind on its S.E. border; and being a retrograde wind, minus the progressive velocity of the storm, as well as exterior to its severest action, it caused little prostration; this effect being chiefly produced by the closing wind from the N.W. quarter, on the cornfields, after the S.E. portion of the storm had passed from Connecticut.

On these points I feel it to be right to speak with that confidence which a knowledge of the facts inspires: having spent several days in Berkshire county, Mass., immediately after the storm, and having also traversed its field of action, on different routes, for more than 60 miles, on a course transverse to its line of progress, and for 40 miles in the opposite direction, at the time when the facts of the case and the effects of the storm were fresh in existence, and in the minds of every observer. My original account in the American Journal of Science, from which it is now attempted to force a conclusion in favour of the centripetal theory, was couched in very general terms, having reference not so much to distinctions of time and exact direction, as to other considerations of a more general character; and the use of the qualified phrase, "*about the same period*," was then thought sufficient to prevent such a misconstruction as is now attempted, in support of a newly conceived theory.

We find in the two succeeding paragraphs, (p. 151,) that Mr. Espy has fallen into a similar error, by assuming, once more, that the S.E. and N.W. winds noticed in Connecticut, and also a S.W. wind which one account states to have followed or closed the storm at New York, were simultaneous parts of the gale, blowing in a rectilinear direction towards a point westerly of Middletown. The error, I believe, has been sufficiently exposed. In the next paragraph, he says: "We have no account how the wind blew to the N.E. of the point in Connecticut, towards which these currents blew, but as the wind set in from the N.E. in front of the storm, wherever we have any account, [?] it is highly probable that here too the wind was blowing from the N.E. at the same time." p. 151.

The last fact assumed here, is perhaps one of the grossest errors that I have been called to notice; as will be obvious I think to every one who ex-



amines the various accounts of this storm. Its commencement from the S.E. quarter at Hartford, Springfield, and Worcester, as well as other places "in front of the storm," I should think could hardly have escaped his research: but lest he should attempt to reject these, I quote the following, from a locality which appears to be N.E. of the point above alluded to.

*Northampton, Mass., Sept. 5.* A heavy storm of wind and rain from the S. and S. E., passed over this town on Monday evening last. One of the court house chimneys was blown down, and a barn belonging to Mr. Enos Cook. Considerable injury was done to orchards; trees were uprooted or shattered to pieces. Cornfields are prostrated.—*From N. Y. Gaz., Sept. 13.*

The S. wind first mentioned here, I presume to have been the fresh southerly wind which immediately preceded the gale, and which passed over Connecticut, heavily charged with condensed vapour, or sea scud, such as not unusually produces rain higher up the country. The direction of the gale here, as well as throughout this region, appears destructive to the above centripetal hypothesis.

We have seen from the foregoing, that this storm did not "blow inwards" from "its borders towards its central parts," as Mr. Espy next alleges; but circuitously, in the manner of a great moving whirlwind, and revolving constantly around its progressive axis in the direction from right to left, or contrary to the hands of a watch which lies with its face upward.

We next find, that on closing up his allegations Mr. Espy does "not say that the wind blew to one central point from every part of the circumference;" he says "this is hardly to be expected, even if the storm was perfectly circular, for reasons too obvious to require explanation." p. 151. I agree most entirely in this conclusion: but which was probably intended only as a qualified indulgence to his theory—an indulgence which he no where allows to the whirlwind storm. The probable origin of this concession I may have occasion to notice.

Mr. Espy next considers it "almost certain that the diameter of the storm was longer from S.W. to N.E. than from S.E. to N.W.," and estimates the former at "more than 300 miles;" and that the diameter from S.E. to N.W., when the storm reached Connecticut, certainly was not more than about 100 miles—for at Providence it was not of a violent character, and about 50 miles N.W. of that city, the centre of the storm passed, so that here its semi-diameter was only about 50 miles." p. 151.

We have already seen evidence of the incorrectness of this conclusion; and it is not long since Mr. Espy pronounced a storm which was more irregular in its development, as being "so nearly round that it would be an affectation of accuracy" to consider it otherwise.\* We have also found a S. E. wind reported at Northampton, which place, "as the crow flies," is more than 70 miles from Providence; not having yet reached the line of N.E. wind which he assumes for the centre of the storm. This inquiry is not for the violent portion of the storm, but for its extreme width; and we have already found its extreme border to have been far eastward of Providence, at which place its violence was sufficient to prostrate trees and buildings, a rope walk among the number. On the other hand, I find it stated that the steamboat Chancellor Livingston was detained no less than

\* Journ. Frank. Inst., Oct. 1838, p. 225.

four hours by the gale at Poughkeepsie, which is 80 miles up the Hudson. We have thus a great addition to Mr. Espy's dimensions in this direction; and if we estimate its extent N.E. and S.W. by its duration at Norfolk, Capes of Delaware, and New York, where he claims *the centre* of the storm to have passed, it will afford little evidence of the elongation in figure which he has attempted to show.

We next find Mr. Espy resuming his aerial speculations; with which I have no wish to interfere. The avowal that the "hypothesis of a whirlwind" does not explain the cause of the rain and hail, is both unphilosophical and foreign to the issue of fact in which he has joined. The attempt to find a universal solution of nearly all atmospheric phenomena, in the theory of aqueous condensation, in the present state of our knowledge, appears like "advancing backward" towards the dark ages of meteorology and other sciences:

The attempt which is next made to press Dr. Mitchell's prognostics, quoted by me, into the service of the centripetal theory, is an example of the facility with which Mr. E. causes nearly all atmospheric phenomena to perform the same service.

"When a haze or cirrus is seen [from New York] over Staten Island at S.W. or more southerly, [say S.S.W. and S.] the storm of the succeeding day will blow from the *north-east*, but if it appears over the Jersey shore of the Hudson from W.S.W. to N.W., then the storm is expected to blow from the S.E. From this it would appear that the wind blows towards the cloud of an approaching storm." p. 153.

Thus, if I understand Mr. Espy, when the cloud first seen southward of New York has moved 12 or 18 hours in a N.E. direction, so as to be found over Massachusetts Bay, or farther distant, and the great body of the storm is spread over the ocean, nearly opposite New York, *then* "it would appear" that the N.E. wind at the latter place "blows towards the cloud of an approaching storm." (!)

The observation ascribed to Dr. Thomas, of North Carolina, on the longitudinal extent and appearance of certain thunderstorms, as they appear in the western horizon, and their smaller extent from S.E. to N.W. is such as must have been often made by every observer. These appear to form on a line of disturbance or disruption, where a portion of the lower wind becomes connected with, or is broken by, a colder, or higher, stratum. But I am at a loss to determine what analogy or connexion these appearances can have with the storm of 1821, or with others of a like character. This attempt at analogy appears as remarkable as the avowal which precedes it, (p. 153, line 8, 10,) that all "phenomena connected with storms" "are explained by the evolution of caloric in condensation of vapour," an avowal well suited to the ultraism of Mr. Espy's calorific theory.

Mr. Espy having closed his "investigation" of my storm of 1821, in his capacity of meteorologist of the joint committee, and after claiming both fairness and demonstration as pertaining to his deductions above noticed, adds the following, which perhaps is intended as an additional "demonstration."

"Moreover, as the wind on the S.E. side of the storm had been blowing all day, before the storm came on, from the S.E., and on the N.W. side of the storm from the N.W., there appears no reason for the motion of the storm from the S.W., but the uppermost current of the atmosphere, which is known to be always moving in this direction." p. 158.

So far as I know, we have never learned that "the uppermost current of

the atmosphere" is always moving from S.W.; or that any observations have ever been made upon its movements. We know from ocular demonstration, as well as from other indications, that *several* horizontal currents are usually, if not always, manifested in the atmosphere, pursuing their several courses, sometimes over vast surfaces, one above another; but it is only the lower and denser of these currents of which we can often take cognizance. But, if by "the uppermost current," be only meant those currents which usually prevail in the common region of the clouds, then the *known direction* here asserted, requires much qualification. For, having made more numerous and longer continued observations upon this subject, recorded daily, than have yet come to my knowledge from other sources, I am able to say that these *currents* usually prevail, in this region, between S. W. and N. W.; and in the greatest proportion from about W.S.W.

Nor do I perceive what influence an "uppermost current" could have in driving forward this storm. The "evolution of caloric in the condensation of vapour," both before and during the storm, having apparently been confined to the lower atmosphere or wind, the course of the storm, upon this theory, I should think, ought to have been with the south-easterly wind which is so generally reported previous to the access of the gale, and which appears to have prevailed beyond its borders. Besides, an upper current in the region spoken of, as may be often seen, and is recognized by Mr. Espy, appears to produce no appreciable effect upon the course or velocity of the wind, or stratum of atmosphere moving below it. I can see no reason, therefore, why the "uppermost current" should govern the course of the storm; unless, indeed, it were to encounter the vast ideal spire, or ascending column, which Mr. Espy erects in the centre of his centripetal storm. But of this we can perceive no evidence in the undisturbed movement of the higher stratum, which is often witnessed for days before and also immediately previous to the arrival or passage of the centre of the gale; the placidity of which higher current appears to remain undisturbed. Moreover, according to analogous statements of Mr. E., the top of this spire should perhaps be considered as being "blown off," or else spreading out, like a great mushroom, in space which was already occupied by these higher currents!

In my first paper, I attempted to indicate, in a general manner, the causes which must govern the course of our great storms, as being found in the *general course of the great inferior currents of wind*, of which I considered the trade winds as forming an integral portion.\* The general course of the aerial currents at the common height of the clouds, is here deemed important, only so far as it may indicate the *generally uniform course of the inferior atmosphere*, separated as these higher currents are, from obstructions and deflexions, the eddyings or gyrations, as well as retardations, which pertain to the surface winds which lie at the very bottom of the aerial ocean. But it appears from my long course of observations, as well as from facts stated elsewhere, that an upper current of wind can have but little influence upon the course, or blowing direction, of the mass or stratum of wind lying beneath it, as before noticed.

I may here notice, that in his "Examination," &c. in the Jan. No. of this Journal, Mr. Espy speaks of the known S.E. direction of the upper wind, flying above the trade winds in the West Indies, (p. 49) but what is the extent or foundation of this knowledge does not clearly appear. Is it

\* Silliman's Journal, April, 1831, vol. xx. 50 51.

founded only on the known courses of the storms in that region, which I had pointed out? It may be possible that Mr. Espy has not well acquainted himself with the various directions and anomalies of the trade winds in those regions; especially with the general movements of these winds as exhibited below the medium height of the clouds: although I admit, that the very lowest or *surface* current of these winds, is most frequently north-easterly. But that which he appears to call "the uppermost current," has, in those latitudes, been generally reported from the S.W. quarter; and as a mere *upper current*, let me add, would be as likely to control the direction of these storms while in the West Indies, as in the United States.

Although unpractised in controversial discussion, it has been my design, in this defensive appeal, to treat Mr. Espy's pretensions with fairness, as well as with particularity; such as the importance of the issue appears to demand; and I have regretted that he did not consider it desirable to confine the discussion to a few of the most important and distinguishing facts and characteristics which are alone necessary to a decision of the question.

It appears to have been established by my inquiries, that there is a line pertaining to the interior path of a violent storm, on one side of which, the changes presented in the direction of the wind are in the order from left to right, coinciding with the apparent course of the sun in northern latitudes: while, on the other side of this line, the order of change presented by the wind is against the sun, or from right to left. Now, if on and immediately contiguous to, this line, the direction of the gale previous to its crisis and change of direction, be found opposite to the course of the storm, i. e. in the direction which is retrograde, but parallel to its line of progress, in accordance with the centripetal theory, then the case must go for Mr. Espy. But if the direction of the wind on and near this line, previous to the crisis and change of the storm, be found in a direction which is *transverse* to the general course of the gale or its line of progress, in conformity with the theory of a whirlwind, then the *rotary* action of the gale is established. The approximate accuracy with which the line of the axis or pivot of the storm, may sometimes be fixed, and the extremely divergent character of the winds here specified, render the question, in such cases, of easy determination; and for testing the two theories, it was unnecessary to extend the inquiry or discussion beyond this single and tangible point.\*

There is still another and conclusive test for the two theories in their application to storms. It must be obvious, that if Mr. Espy's centripetal theory be the true one, then the various directions of wind in a storm will as well correspond with a whirlwind turning to the *right*, as with one turning to the *left*; and one course of rotation can as readily be made out from the facts collected, as the other. Now, I invite Mr. Espy to apply this rule of examination to the storm of 1821, and also to the various storms which are noticed in the work of Col. Reid. True it is, that on the whirlwind theory, this other result would require every wind to be reversed in its direction; but, if Mr. Espy is right, no such reversal will be necessa-

\* This test will apply equally to the traces or prostrations in the paths of tornadoes; or, if these be the effects of a wind blowing from all sides directly towards the centre of the tornado, then the predominant effects of the wind *in the centre of its path*, will be found *parallel* to its course;—but if the effects here, be *transverse* to the line of progress, then the prostration was occasioned by a whirlwind: no matter in which of the transverse, or longitudinal, directions the effects may have been produced.

ry; for in such cases the reported direction of the several winds at various places will be found to correspond as well with one direction of rotation as with the opposite; both being equally remote from his centripetal theory.

Let the advocates of the latter, who remain unsatisfied, make this trial, with our figures before them.\*

An argument for the theory of rotation may be found in those sudden irregularities and in the light and uncertain winds which are sometimes exhibited near the centre of a storm; for, on the centripetal theory, the relative condition of this portion of the storm would appear liable to little change. But, in a whirlwind storm, the winds will be found to have an axis of *progression*, as well as an axis of rotation. These axes cannot coincide in their path, but the former will be found considerably to the left of the latter, or on the coast of the United States, further to the N.W. We see here a cause for many of the anomalies and irregularities of action which are found near the centre of a gale; and which, according to the centripetal theory, would not be likely to occur.

Another argument for the whirlwind theory, is found in the increasing and sometimes very extensive expansion of the lull of the storm, particularly in greatly extended storms, where the passage of the central lull, and the continual depression of the barometer, is sometimes of more than a day's duration. This appears to be due to the centrifugal influence of the rotary action; but it is difficult to perceive how this enlargement of the central lull under a continued barometric depression, can be reconciled with the centripetal theory.

In comparing the accounts of the storm of 1821, the inquiring reader will hardly have failed to notice the unequal force and duration of the westerly winds which closed the storm, as compared with the more generally violent and longer continued winds from the eastern board. This peculiarity frequently attends the development of our coast storms, which sweep, as in this case, partly over the sea and partly over the land; and seems to be due to the greater obstructions which are offered to the gale by the continental surface. The results seem accordant, however, with a generally circuitous action; these westerly winds, at least the south-westerly, being often found strongest at a distance from the coast.

Observations made on well developed storms of a later date than that which has been considered, have shown the distinguishing characteristics of the whirlwind storm. On the line of lull in the centre of the storm, the wind has been observed to set in, not contrary to the course of the storm, according to Mr. Espy's theory, but more nearly at right angles to this course, and continuing with increasing violence in nearly this direction, till the arrival of the lull; after which the wind commences to blow, more or less suddenly, from nearly the opposite point of the compass, and continues in that direction till the close of the gale. Such was the storm of April 28th, 1835, at New York, on which observations were made with great care. These and like observations would appear to be entirely conclusive of the question.

I have never known a storm in which the line of the central lull has corresponded to that of an initial wind blowing opposite to the course of the storm, and the lull followed by an equally strong wind from the opposite

\* The facts necessary for this examination, as relates to the storm of 1821, are found in this Journal for March, 1839, p. 153—158. This test is too important to be omitted by those who remain in doubt on this subject.

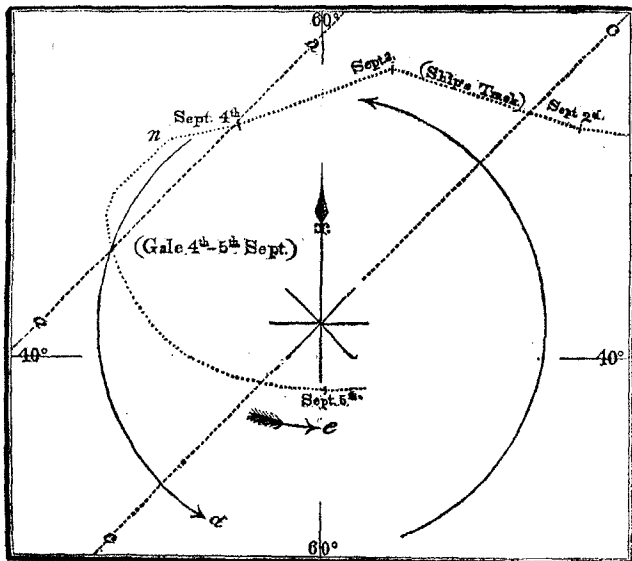
quarter, blowing parallel to the progress of the storm; nor am I yet prepared to believe that such a case can be produced.

In illustration of the rotary character of the Atlantic gales, I present here the case of a N.E. gale which was encountered at sea on the 4th of September last, off the Sable Bank. This storm, like three others which immediately followed, passed at sea, not far from our coast, and apparently on a track leading far to the northward. The account was kindly furnished by Thomas H. Sumner, Esq., master of the ship Cabot, and was drawn up by him soon after the close of the gale. At noon on the 4th, the ship's latitude by double altitudes, was  $42^{\circ} 12' N.$ , lon.  $61^{\circ} 5' W.$ , ship steering W.N.W., and the wind at N.E., soon increasing to a severe gale. At 4 P. M., reduced to close reefs. The gale had now so increased that it was deemed hazardous to heave too, and the ship was kept before the wind; which gradually hauled to the N. At 11h. 30m. P. M., it was a perfect hurricane. At 2 A. M., [6 A. M.?] the wind had hauled round to W.N.W., and at 2 P. M., the storm had so far abated that the ship resumed her course. Lat. at noon on the 5th,  $39^{\circ} 39' N.$ , lon.  $59^{\circ} 59' W.$  The following are the approximate courses from the log book from noon on the 4th, to noon on the 5th, corrected for variation.

Courses.	Hours.	Distance.	Courses.	Hours.	Distance.
W. b. S.	4	40 miles.	S. E. b. S.	2	22 miles.
W. S. W.	1	10 "	S. E.	2	21 "
S. W. $\frac{1}{2}$ W.	4	44 "	E. S. E.	2	20 "
S. b. W.	1	11 "	E. b. S.	4	40 "
S. b. E.	2	24 "	E. b. S.	2	18 "

250 miles.

The winds during this period, as since taken by me from the log-book; were N.E., N.N.E., N., N.N.W., N.W. b. W., W.N.W., and W. b. N.



I annex here a figure showing the track of the ship previous to, and dur-

ing, the gale. The line *a a* will represent the general route of the centre of the storm, according to the centripetal theory, but, viewed as a whirlwind, the centre may have passed near the line *c, c*. In plotting the courses, an approximate correction is made for the angles resulting from a reference of the course to the points of the compass, and also, for the heading off and continued set of the Gulf Stream. The curved wind arrows are drawn from a fixed centre, but owing to the continued progress of the centre with the body of the storm, it may be presumed that the direction of wind represented at *d*, would, from this cause, have been carried forward in its position; as for example, at *e*, or to a more advanced position.

Had the N.E. wind here, been at or near the centre of the storm according to the centripetal theory, not only would the ship have been met, perhaps after a lull, with a violent wind from the S.W., but a large portion of the ship's track, from 4 P. M. on the 4th, would probably have fallen under the easterly winds, which, upon this theory, belong to the opposite portion of the storm; by which the ship would again have been driven to the westward. But the continued curvature of the ship's track, while running before the wind for so great a distance eastward, appears to demonstrate that the storm was of a rotary character, whirling to the left.

Did our space permit, I might here notice in a more particular manner, the "examination" of Col. Reid's work which Mr. Espy has attempted in the January No. of this Journal. The survey which has here been taken of his examination of the storm of 1821, may serve, however, to illustrate the extent of his misconceptions in analogous cases. We are also furnished by Mr. E. himself, with a key to the illusion under which he appears to have fallen in regard to these storms. He says:

"On reading the logs of the several ships, I kept the map of the particular storm open before me, and drew my pencil across the point where the ship was, drawing an arrow so as to exhibit to the eye which way the wind was blowing at that time in that locality. When several logs were read, and arrows made in every locality, I was not a little pleased to see, in all the storms, decided proofs of an inward motion of the air." January No., p. 39.

This fallacy is also brought before the eye of his reader, in various figures inserted in the same paper, and appears to have had a controlling influence upon his mind from the beginning of his inquiries.

Perhaps it is not generally understood, that the traces of the action of an ordinary whirlwind, as found in the prostration of corn, and other objects, along its path, always point inward, and at first view appear not greatly unlike the action of two parallel lines of opposing winds blowing simultaneously towards each other. From causes which I think are obvious, this effect is more strikingly exhibited in small tornadoes, than in large storms of the whirlwind character; but the *coup de œil* of the effects marking the various and successive directions of the wind, when thus blended together, is, in the latter case, not unlike the former. But a careful analysis of these effects, with proper attention to the order of time, place, and succession, will not fail to demonstrate a circuitous or whirling action.

These effects were well exhibited in the track of the New Brunswick tornado, (N. J.) of June, 1835; and which corresponded to those which I have examined in the tracks of several other tornadoes of like character: and if there be any effects which amount to a demonstration of a constant whirling movement in the wind, they are certainly to be found in these appearances. Small whirlwinds, exhibiting like traces, have sometimes passed

under observation and the entire circuit of gyration been fully taken in by the eye. These peculiarities of aerial motion have been noticed from time immemorial, and have been clearly designated by terms which seem to have found their way into all languages, through all ages. But according to the discoveries of Mr. Espy, founded, perhaps, on these inward appearances, the observations in all ages, on which these terms have been founded, could have amounted to little else than an ocular deception; and an obvious whirlwind can be no whirlwind, after all! but, strange to say, the wind in such cases has blown from all sides, almost, if not directly, inward,—each part opposing every other part in its onward motion, until compelled, for want of room, to turn directly upward in an ascending column; or, perhaps, I should say, *drawn* upward by a principle of calorific levity! To say nothing here of the physical impracticability of continued movements of portions of contiguous atmosphere in opposing directions, I would suggest to the advocates of this centripetal theory, to inquire whether these inward appearances, on which they rely, are not the necessary results of whirlwind action, and such as are uniformly exhibited in the path of destructive whirlwinds? Notwithstanding the illusion of these inward appearances, it will be found that each single effect, when plotted in connexion with other effects which were produced *at the same instant of time*, may serve to demonstrate the whirling action.\*

The great mass of interesting facts, and the clearness of the illustrations found in the work of Col. Reid, are such, however, as will probably carry conviction to all minds not preoccupied by opposing theories or opinions: and it is not probable that the valuable developments of the law of storms which are found in his work, can be obscured or set aside by the opposing views and labours of his ingenious but mistaken examiner.

It was my intention to have introduced here, some further remarks on the errors or fallacies which are apparent in Mr. Espy's reports on various other storms, as chairman of the joint committee on meteorology; but the space which has been already occupied, renders it necessary to relinquish this design. I would however, notice in passing, that his selection of these storms has not often fallen upon those of a strongly marked character and in such a field of action, as would leave little room for mistaken or imaginary inferences; that in no case, save the last reported, has the collection and development of the facts, been such as the character and objects of the committee seemed to demand; and that in nearly all of the *twelve* cases, thus put forward and relied on by Mr. Espy, there has appeared, on examination, sufficient evidence for the refutation of his peculiar positions.

The most important and creditable of these labours of Mr. Espy, relate to the two storms which simultaneously visited our sea coast and interior, on or about the 17th of March, 1838. This coast storm Mr. E. has blended with the fall of snow and rain which appears to have prevailed over a large interior portion of the United States at the same period, attended by no remarkable development of wind, and a like moderate effect upon the barometer; and which, on its arrival near the coast, appears to have blended with the smaller and more strongly developed storm or gale which was then sweeping along our seaboard. The latter, favoured probably in the action of its north-western limb by the diffusing and concurrent action of the in-

\* I do not here notice the involuted spiral course of the wind inward and upward, in these tornadoes; not deeming it necessary to the illustration of the points now at issue.



land storm, exhibited its N.E. wind with unusual violence. But in place of the continued and strong north-westerly wind, which, in regular and well developed storms, immediately follows, *the barometer remained depressed, and no westerly gale followed.* But in the few marine accounts given by Mr. Espy, the development of a westerly gale on the opposite limb of the coast storm, off at sea, was clearly distinguishable; with other marked characteristics of a whirlwind storm.

These general conclusions, I think, will be obvious from even a cursory examination of Mr. Espy's chart and evidence illustrating this storm, at least to those who are accustomed to examine the phenomena of the whirlwind storms; and it will readily be seen, that the violent N.E. gale near the seaboard, was of a different character from the more general inland storm; as is apparent also from the greater fall of the barometer near the coast; which is always found to be greatest near the true centre of the gale.

There are two important facts connected with the development of this storm, as exhibited by Mr. Espy, which have strong claims to the attention of those who advocate the centripetal theory. The first is, that the collection and arrangement of the evidence relating to the course of the winds and their delineation upon the map, has brought Mr. Espy to acknowledge "that there is no one point at which all the arrows, if prolonged, would meet;" one arrow pointing to "somewhere in North Carolina," and another to "somewhere near the N. part of the storm."\* He would fain believe, however, that certain of the strong exterior winds would meet "very little S. of the centre," and in conformity with his theory. But it is difficult to see how this storm, as developed by him, can afford any support to his peculiar views; and he obviously overlooks the connexion of the N.E. wind, E. of the Alleghanies, with the storm which was sweeping along the coast, and which was made apparent by a report of the gale at W.S.W., two and three days before arriving at the Capes, by the ship Sabina, at Philadelphia.

It is a fact equally remarkable, that if we set one foot of a pair of dividers upon the central point which Mr. Espy has marked for the storm of the 17th, and, with a pencil at the other foot, sweep through the several geographical points in and near the field of his storm, W. of the Alleghanies, we shall then find that the direction of the wind in the places from which reports are given, appears to correspond with *a great circuit, or whirlwind, turning to the left.*

Now, when we consider the diversity of surface and position in this great inland region; the distances and the inequalities of elevation, which in some cases might expose the locality to the action of other strata of winds; and the disturbance of direction which possibly might have resulted from the contiguity or influence of the violent coast storm, together with the liability to inaccuracy in the reported observations; this result may well be considered not only as remarkable, but of great value.

The reader is invited to test the examination in the manner mentioned, at the following localities, as they are numbered on the chart which Mr. Espy has attached to the report under consideration, viz.

Locality No. 6. On the 16th and 17th March.	Locality No. 14. On the P.M. of 17th.
Locality No. 7. On the 16th and forenoon of 17th.	“ 15. “ 17th.
	“ 17. “ 17th.
	“ 18. “ 17th.

\* Journ. Frank. Inst., Oct. 1838, vol. xxii, p. 224.

Locality No. 11. On the 17th.	}	Locality No. 20. On the P. M. of 17th.
“ 12. “ 17th.		“ 27. “ 17th.
“ 13. “ 17th.		“ 28. “ 17th.

These, I believe, comprehend *all* the reports from localities within or near his field of the storm for the 16th and 17th, except that portion which falls within his circle for the storm of the 18th, which is omitted for the reason specified. In three of the above cases only, is it found necessary to make a distinction between the winds of the morning and evening, and if the whole were to be referred to noon on the 17th, it is not improbable that the coincidences would be entire. The most divergent direction of the wind from a circle which I have here found, according to the wind arrows on the chart, comes very much nearer the circuitous or whirlwind movement, than towards the central point marked for the 17th, or any other approximate geographical centre. It should be remembered, that these localities are scattered over a range of country extending from near Lake Ontario to the northern extremity of Alabama, and from the Alleghany Mountains to the middle portions of Indiana.

If we now examine, by a like test, the reports from localities which remain in the field assigned for the storm on the 18th, we shall also find a large portion of cases in which the direction of wind conforms, mainly, to an axis of rotation moving eastward along the coast. But as these reports relate chiefly to the storm of the seaboard, with which the land storm had become blended, I forbear to enter upon a more extended analysis.

We cannot suspect Mr. Espy of having developed these facts for the purpose of sustaining the whirlwind theory of storms; and these results, though still imperfect, may serve to show the value of careful and widely extended observations, when collected and brought into view, as in this report. Ill chosen, as I think was this storm, for the object of deciding the important question which Mr. E. has raised, yet the facts thus obtained and developed in relation to a complicated and somewhat anomalous exhibition of weather, such as is not unfrequently found in these latitudes, are none the less valuable in meteorology: and I hope to see many such efforts on the part of Mr. Espy and the able committee to which he acts as meteorologist. I will only add here, that I have been able to collect additional information relating to the above storm; having extended the inquiry in various directions at sea, as far eastward as the bank of Newfoundland.

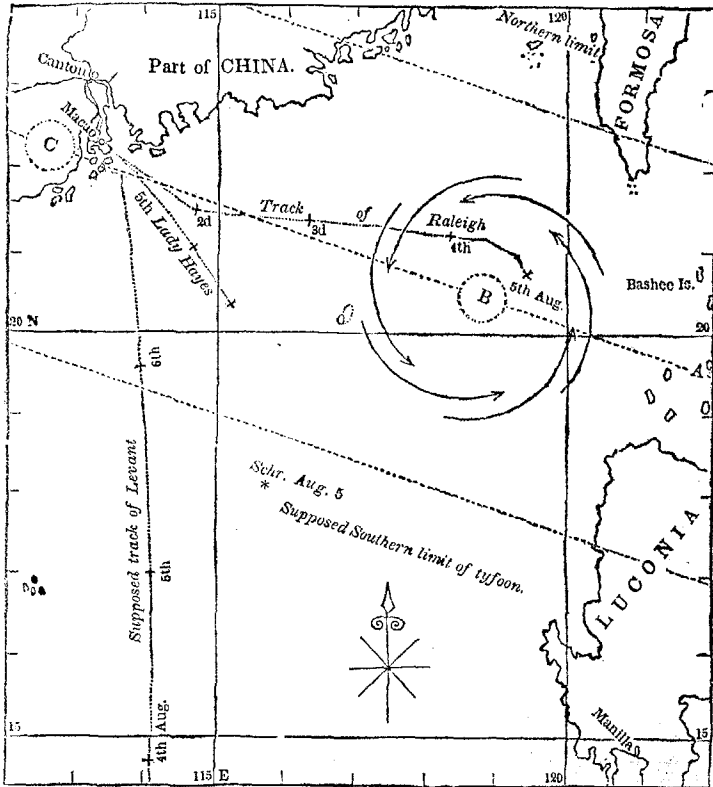
New York, May 18, 1839.

#### POSTSCRIPT.

Since the above was sent to press, the continuation of Mr. Espy's examination of Col. Reid's work, &c. has appeared in the April number of this Journal. The character of this additional matter appears, however, to correspond so nearly with that relating to the storm of 1821, which we have now reviewed, as hardly to require any further reply; except as the present opportunity may seem to invite a passing notice. In his further notices of Col. Reid's storms, we again observe the continued blending of the phenomena which pertain to different periods of a storm, into one forced connexion, as if occurring at the same moment of time, and which is best refuted by the reading of Col. Reid's book, and an attentive consideration of the facts which are there recorded.

In copying my evidence respecting the Raleigh's typhoon in the China Sea, which had also been noticed by Col. Reid, Mr. E. has neglected to

present his readers with the geographical sketch by which it was accompanied; which is here inserted. By referring to this map, in connexion with the annexed synopsis of the evidence, the reader may determine for himself the rotative character of this hurricane: although Mr. E. confounds with the regular action of the storm, the light N.W. wind which preceded the gale at Canton, and the S.E. wind by which it was followed.\*



From the evidence which I have collected relating to the storm, we arrive at the following facts:

1. That the Raleigh met a gale which set in with the wind at N., veering round by the E., to S.E. and S.
2. That at the harbours and roadsteads inside, (Macao, Kumsingmoon, &c.) as well as at Canton, the gale occurred at a later period, and the wind also set in at N. and veered to E. and S.E., in a manner similar to that reported by the Raleigh.
3. That with the ship Lady Hayes, off the islands at the mouth of Canton river, the wind also set in at N.; but the ship steering S.E. by E. under a

\* On this map, the track of the Levant was laid down by estimate, before Captain Dumaresq's Journal was received, and should have appeared somewhat further to the westward. The position of the Levant at noon on the 6th, was a few miles N.W. of the position indicated on the map.

press of sail, (and doubtless falling off from this course with the heavy sea from the eastward,) the wind, towards the middle of the gale, began to veer towards the W., whence it drew round to S., towards the close of the gale.

4. That the violence of the wind was greater with the Raleigh than with the Lady Hayes.

5. That the gale was experienced by an English schooner, August 8, in lat.  $18^{\circ} 2' N.$ , lon.  $115^{\circ} 50' E.$ : but the American ship *Levant*, which arrived in Canton river on the 7th, from the southward, did not encounter the gale.

6. That the fall and rise of the barometer at Macao and with the Raleigh, and the strength and changes of the wind with the latter, were such as are often exhibited near the centre of a hurricane; and that the minimum depression of the barometer occurred about *seventeen hours later* at Macao than with the Raleigh.

These facts seem to establish the following conclusions:

1. That the typhoon advanced in a westerly direction.  
 2. Negatively:—that it did *not* pass through the China Sea, from N.E. to S.W., nor on the opposite of this course.\*  
 3. That it was a *progressive whirlwind storm*, turning to the *left*, around its axis of rotation.

4. That its centre of rotation passed to the *northward* of the Lady Hayes, and to the *southward* of the Raleigh and of Canton; and nearly on the line A, B, C, as marked on our chart.

5. That its rate of progress was about 17 miles per hour.

6. That the extent or diameter of the violent part of the gale, as deduced from its duration and rate of progress, was about 400 nautical miles, or equal to six or seven degrees of latitude.

7. That the latter induction accords with the geographical evidence which has been obtained of the visitation of the storm.†

The fall of the barometer in these storms, I have considered as resulting from their rotative action; but Mr. Espy here asserts that it cannot be due to this cause, and for proof, he refers us to his speculations on this subject. But facts are more to be relied on than speculations, and as furnished by himself, on several occasions, they appear to be conclusive against his position. He asserts, “that it would require an *outward* motion of the air from the centre, of 240 feet per second, to make the barometer fall an inch;” but every person who has observed the action of a vortex, and the depression which the rotary motion occasions at its centre, may know this to be an error, and that no such *outward* motion is necessary for diminishing the central pressure.

In professing his acceptance of the test which I had suggested for his theory, as applicable to storms in the West Indies, and to those moving N. E. on the coast of the United States, Mr. Espy wishes me to concede, that when “the wind sets in at N.E. in storms on our coast, it never can change round to N.W.,” which change he asserts to be irreconcilable with the whirlwind theory. But this cannot avail, for such changes, which every observer has noticed, certainly cannot be considered as sustaining his centripetal theory. This appears, however, to be the most plausible of his

\* A writer in the London Nautical Magazine had ascribed a S.W. course to this typhoon.

† Vide Silliman’s Journal for January, 1839, vol. xxv., p. 209—219; or London Naut. Mag. for January, 1839.

positions, and is grounded on his confident, but impracticable, reference to the "extreme border" of a storm, which has already been noticed. There is, evidently, much relating to this matter which Mr. E. fails to comprehend. It is obvious, however, that when a great gale has "set in" at N.E. on our coast, the "extreme border," or influence of the storm in the atmosphere, has already advanced far beyond the observer: it may even have advanced to the distance of some hundreds of miles; as has been seen in illustrating the phenomena which were noticed by Dr. Mitchell.

It had been well for Mr. Espy, if, in applying the proposed test to storms on this coast, he could have found one storm which would have sustained his centripetal theory. He refers us, indeed, to the "numerous examples" which he had already given in the storm of 1821, as "harmonizing" with his theory; but with the true character of this harmony, the reader is already acquainted. In further seeking for facts to sustain his theory under this test, instead of taking cognizance of storms, "as they move in a N.E. direction along the coast of the United States," according to its terms, he has only referred us to certain facts, (perhaps anomalous) relating to Col. Reid's storm of the middle of August, 1837, which are derived from the log books of the *Ida*, *Rawlins*, *Yolof*, and *Duke of Manchester*; facts which occurred on and near the latitude of 30°, where the storm is rapidly changing its course of progression, and which are therefore inapplicable to either branch of the test which I had presented. I can see no reason, therefore, why these cases should have been adduced, except for want of better, while it can readily be shown that these selected cases are quite at variance with the centripetal theory.

It had also been fortunate for Mr. Espy, if in accepting the test for the storms in the West Indies, he could have furnished one clear instance of a hurricane's blowing from W.N.W. or N.W. without material change, until the appearance of the central lull, and then, resuming its violence from the opposite or S.E. quarter, till the close of the gale. If his theory of centripetal storms had been well founded, it would have been easy to have produced at least a dozen such cases. But, when the generalization made by Edwards at Jamaica, that "all hurricanes begin from the N., and veer back to the W.N.W. and S.S.W."—and that "when got round to S.E. the foul weather breaks up,"—is gravely adduced by Mr. Espy, with other facts of like character, as fulfilling the conditions of the test which I had proposed, it becomes evident that there are no facts to be found which can sustain his theory. It may be seen by referring to our figures in the early part of this communication, and adapting them to a *north-westerly* course of the storm, and also by our map and figure relating to the storm in the China Sea, which pursued the same direction, that the setting in of the hurricane at N. in the latitudes of the West Indies, and its *veering* from that point round to W.N.W., and so on through S.S.W. till it ends in the natural current from the S.E. by which the storm is driven forward, is entirely at variance with his centripetal theory, as applied to the centre of the storm's path in these latitudes; while the direction and changes above described are in full accordance with the other facts by which these hurricanes are proved to be great whirlwinds, spinning to the left, and advancing, in the latitudes referred to, in nearly a W.N.W. direction.

I have reason to hope that the expositions which have now been given, will tend, in some degree, to quiet the apprehensions expressed by Mr. Espy in relation to those rules for the practical navigator which are founded, not

on a mere theoretical basis, but on those important *facts* relating to storms, which have recently been brought into view.

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### Bibliographical Notice.

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*Popular Lectures on Geology, treated in a very comprehensive manner.* By K. C. VON LEONARD, Professor at the University of Heidelberg, in Germany. With illustrative engravings. Translated by the Rev. J. G. MORRIS, A. M., and Edited by Prof. F. HALL, M. D. Baltimore: Published by N. Hickman.

We have received the first number of the above work, containing 100 pages, 12mo; and others are to issue as soon as they can be prepared for the press. The author of these lectures is well and advantageously known by his publications on Geology, and the kindred departments of science. The lectures which the translator and editor are now presenting to the American public, were delivered with the laudable intention of giving a popular view of a science of modern creation, but of the highest interest, as it has rendered familiar to the philosopher the nature and history of those successive events which, in the order of Providence, were necessary, and intended to bring the globe which we inhabit from its original chaotic state into that condition by which it was fitted to become the habitation of moral and intellectual beings. Were we to attempt to enumerate the discoveries, and the fair and necessary inductions of the Geologist, they would, to most of those who have not made the science a study, appear to be the creations of fancy, rather than the legitimate conclusions of sober judgment, under the guidance of sound philosophy. It is not only right, therefore, but is most praiseworthy, for the cultivators of this, as well as of other, departments of science, not only to enlarge its boundaries, but to diffuse a knowledge of it by presenting it to the public under an aspect the most familiar and attractive of which it is susceptible.

It appears that popular introductions to geology were almost unknown in Germany prior to this publication, although there are many such in France, England, and our own country; some of these have great merit, whilst others are from the hands of the mere manufacturers of school manuals, the productions of persons much better acquainted with the book market than with the science which they pretend to render familiar. We hail the work before us with pleasure, as the production of a philosopher of a vigorous mind, fully imbued with a knowledge of the subject matter with which his pen is occupied. It is no easy task, however, for one who has rendered himself familiar with the higher departments of any branch of science, to descend sufficiently from his elevation to conduct the inquirer in his first steps; it is in this point that such attempts, most frequently, fail, and from this objection the work before us is not entirely exempt. The published number contains three lectures; the first is devoted, principally, to the subject of mining, including its connexion with geology, and containing a general notice of mines, miners, and mining operations, illustrated by thirteen engravings on wood. We have read this lecture with much gratification; its history and its anecdotes are well calculated to induce in the reader a de-